

HVOF as a Hard Chrome Replacement



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AIR - 4.3.4.1

**NADEP Jacksonville
Materials Engineer**

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HVOF as a Hard Chrome Replacement

**Chrome Plated
Metcut Large
Fatigue Bars
with 4.5" Radius
per ASTM E-606**

**Chrome plated at
NADEP JAX**



HVOF as a Hard Chrome Replacement

**Chrome Plated
PAX LAB
4.3.4.2 Large
Fatigue Bars
with
0.625" Radius**

**Chrome plated at
NADEP JAX**



HVOF as a Hard Chrome Replacement



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HVOF as a Hard Chrome Replacement

Alternate-to-Chrome ID Test Specimen Holder

Baseline for alternate ID thermal spray coatings

Cylinder required modification for Cr plating

Requires plating solution to be pumped through ID

Cylinder ID approx. 3" dia

Anode dia approx. 1.420"



HVOF as a Hard Chrome Replacement

Alternate-to-Chrome ID Test Specimen Holder

Cr used as baseline for alternate ID thermal spray coatings

**Four total runs completed;
22 samples coated**

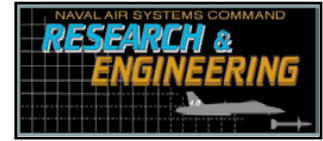
**First test coupon run
completed 26 Aug 02;
11 samples coated**

**Second test coupon run
completed 09 Sept 02;
11 samples coated**





HVOF as a Hard Chrome Replacement



F/A-18 Horizontal Stabilator Piston Rod

P/N 3003130 (Vendor Code 93835)

HVOF Coat short external end with WC/Co/Cr 86/10/4

HVOF Coat longer internal end with WC/Co 83/17

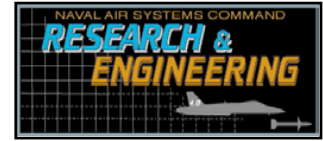
Grind to 8 - 16 μ in Ra finish

Superfinish to ≤ 2 μ in Ra finish

Ship to PAX Lab for additional Hydraulic Actuator seal compatibility testing



HVOF as a Hard Chrome Replacement



AMEC Specifications

**AMEC Meeting No. 172 @ Goodrich Landing Gear -
Cleveland, OH 1-2 August 2002**

**Grinding Spec went out on 28-day ballot
14 Approvals, 5 Disapprovals, 1 Waive
0 out of 52 addressees on ballot**

**AMEC direction: Add statement to Grinding Spec;
Cutting fluids containing amines shall not be used
when grinding coatings which contain cobalt.**

**Reason: Cutting fluids containing amines may leach
cobalt from coatings during grinding.**

Send comments to: Scott.Maitland@goodrich.com

HVOF as a Hard Chrome Replacement

AMEC Specifications

**AMEC Meeting No. 172 @ Goodrich Landing Gear -
Cleveland, OH 1-2 August 2002**

HVOF Coating Specs went out on 28-day ballot

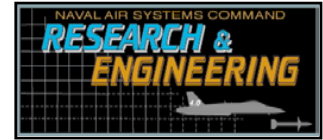
**AMEC 99B: WC/Co powder spec; 16 Approvals,
0 Disapprovals, 7 Waive**

**AMEC 99C: WC/Co/Cr powder spec; 15 Approvals,
0 Disapprovals, 8 Waive**

**AMEC 00AB: Application Spec; 13 Approvals, 1
Disapproval, 8 Waive**



HVOF as a Hard Chrome Replacement



Current Status of P-3 Main Landing Gear

**HVOF MLG Piston installed 26 April 99 on VP-30
Aircraft BuNo 156522**

Aircraft completed PDM at NADEP JAX on 5 Dec 99

PDM extended due to multiple spar cap insertions

850 Landings on HVOF coated MLG Piston (Aug 00)

**HVOF Coated Piston removed from service Aug 00 due
to internal oil leak on ID-2 (NOT HVOF COATED)**

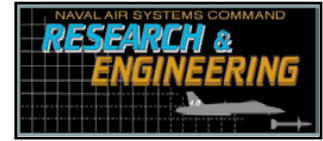
HVOF Coated Strut repaired, sent back to VP-30

Installed on Aircraft 160284 STBD April 25, 2001

1,078 Total Landings on HVOF coated strut (8/23/01)



HVOF as a Hard Chrome Replacement



Current Status of P-3 Main Landing Gear

**HVOF Coated Strut installed on VP-30 Aircraft 160284
STBD side on April 25, 2001**

655 Landings on HVOF coated strut since 4-25-01 (2/1/02)

1,505 Total Landings on HVOF coated strut as of 01 Feb 02

44 Landings on HVOF coated strut since 2-1-01 (9/5/02)

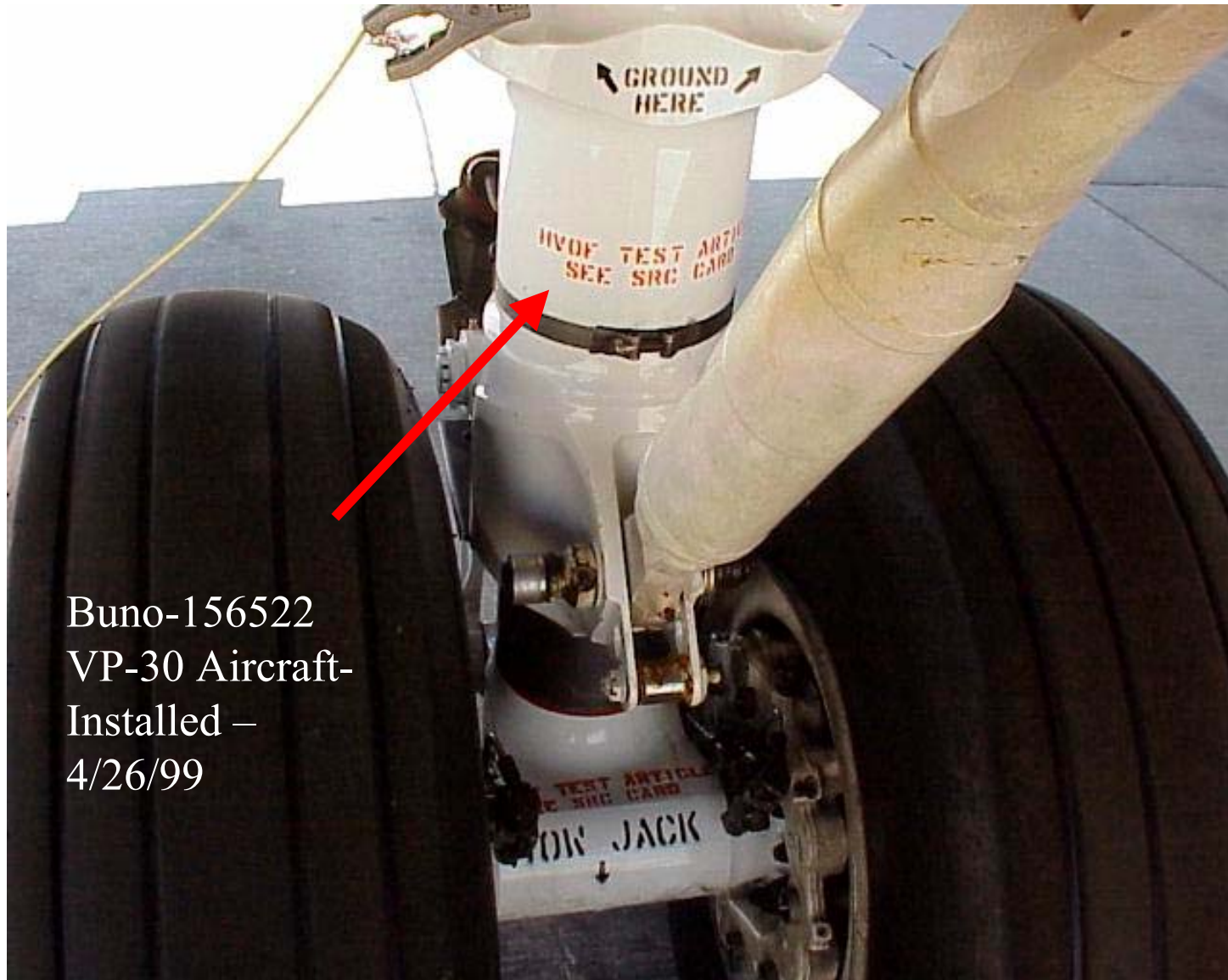
1,549 Total Landings on HVOF coated strut as of 5 Sept 02

HVOF as a Hard Chrome Replacement



Buno-156522
VP-30 Aircraft
Installed 4/26/99

HVOF as a Hard Chrome Replacement

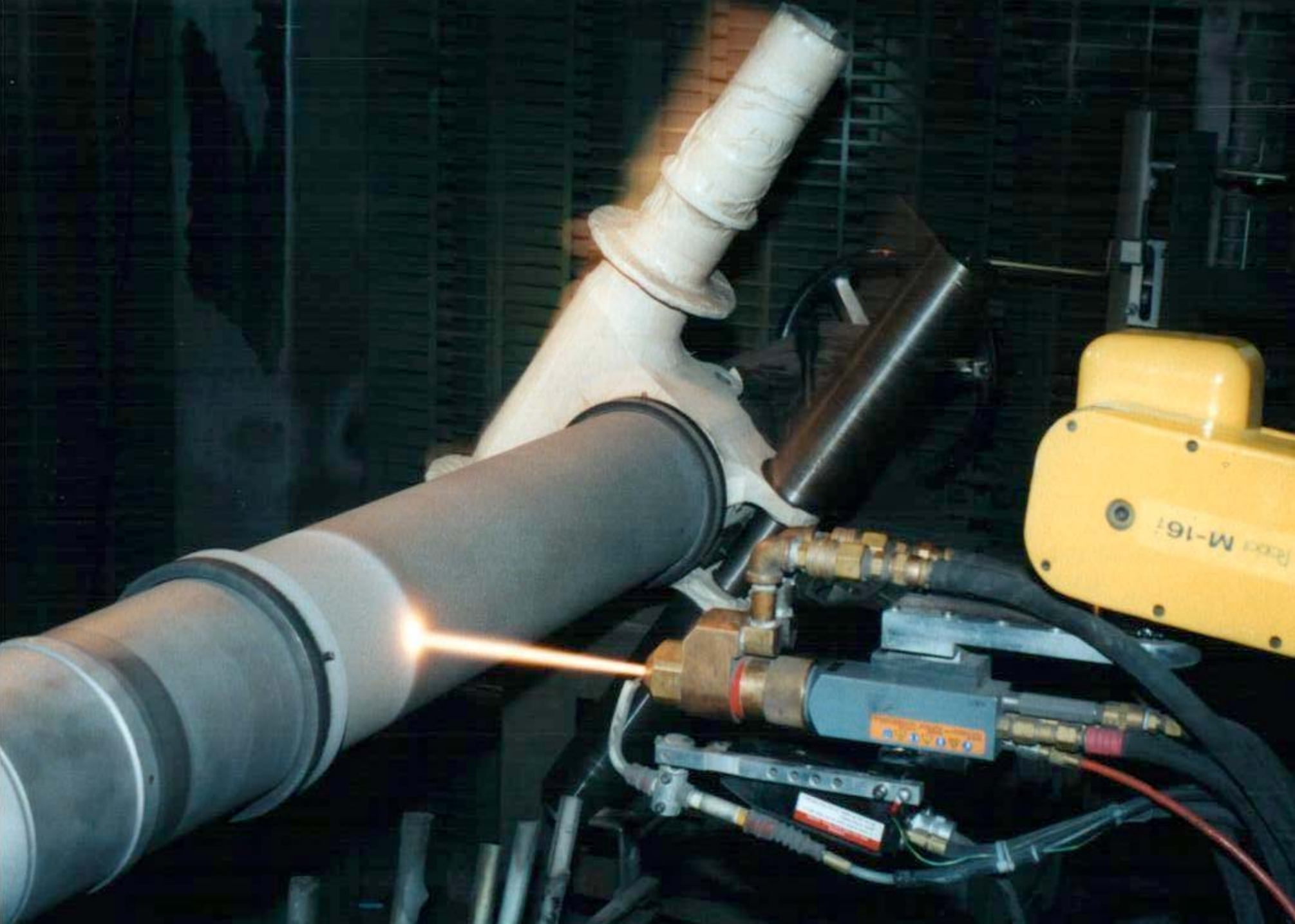


Buno-156522
VP-30 Aircraft-
Installed –
4/26/99

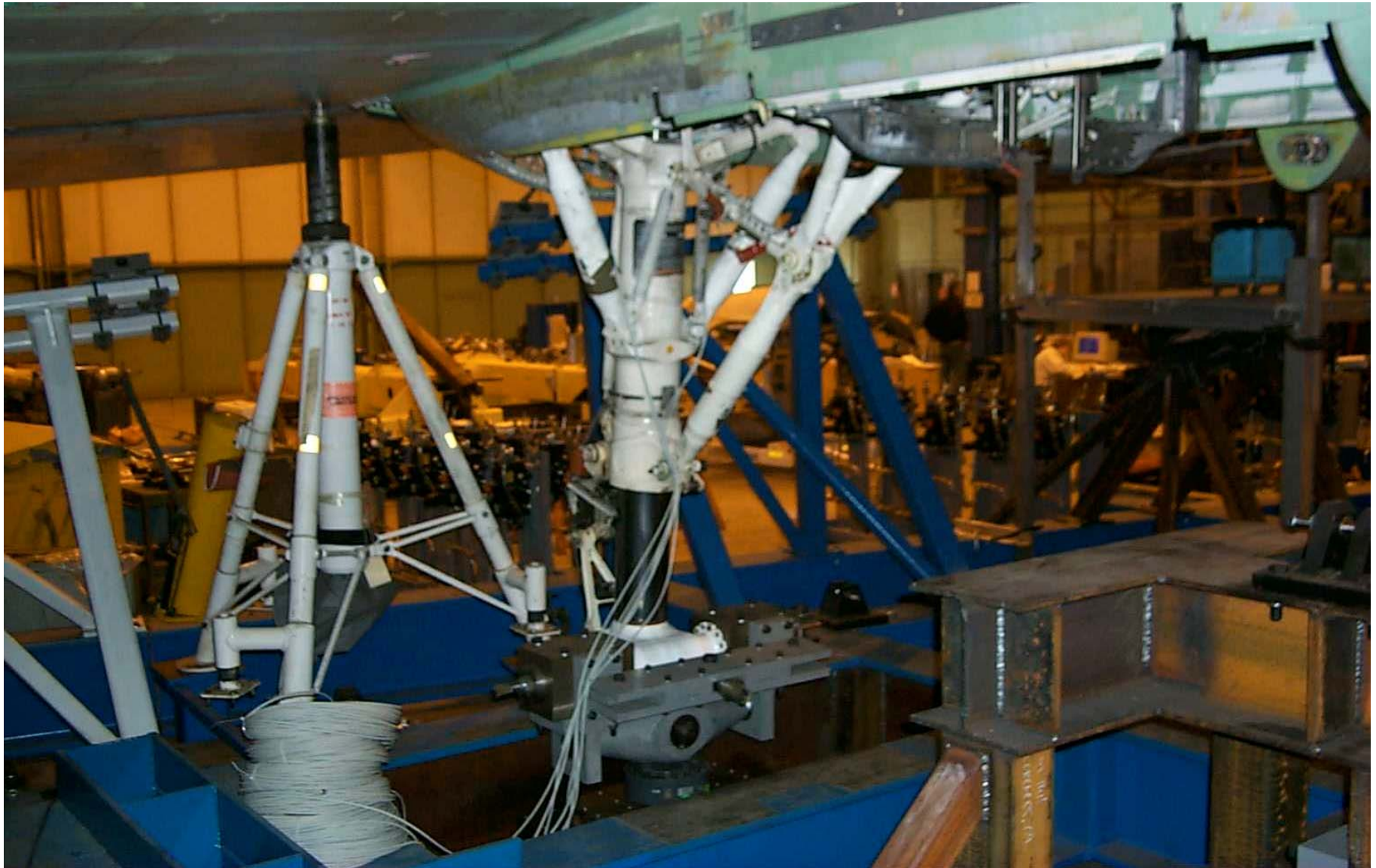
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Second P-3 MLG Piston coated with HVOF WC/Co 83/17

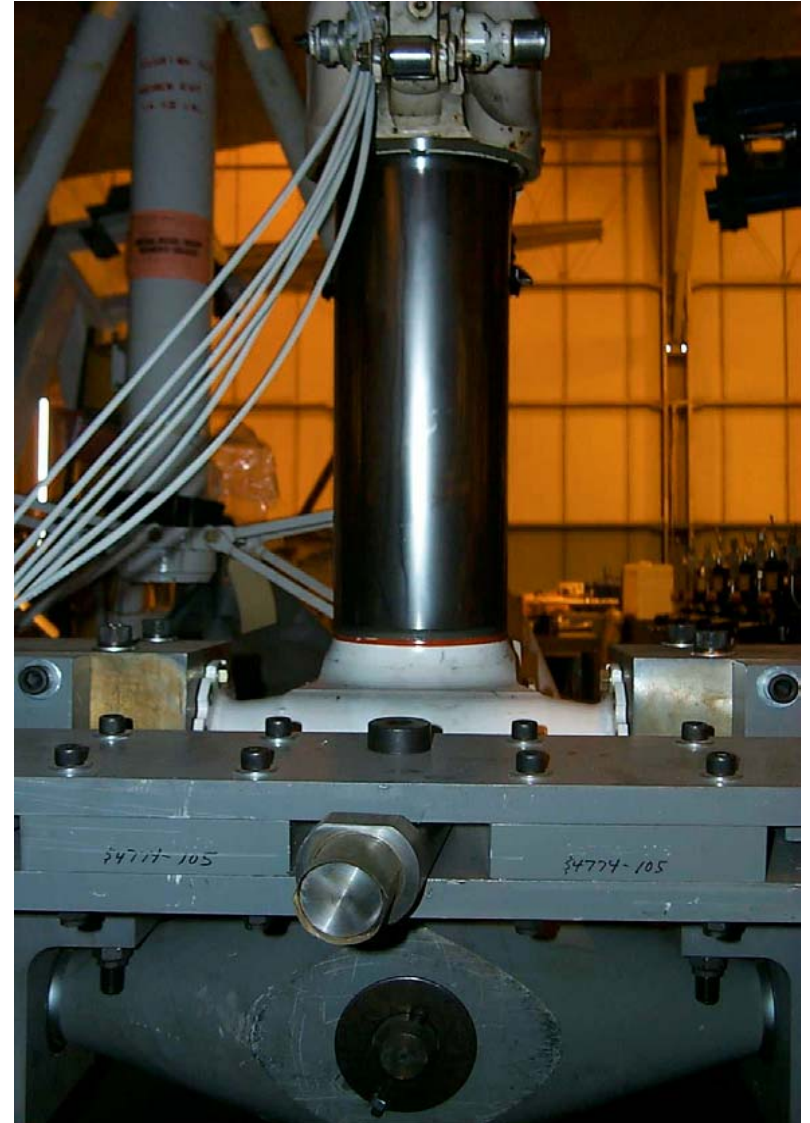
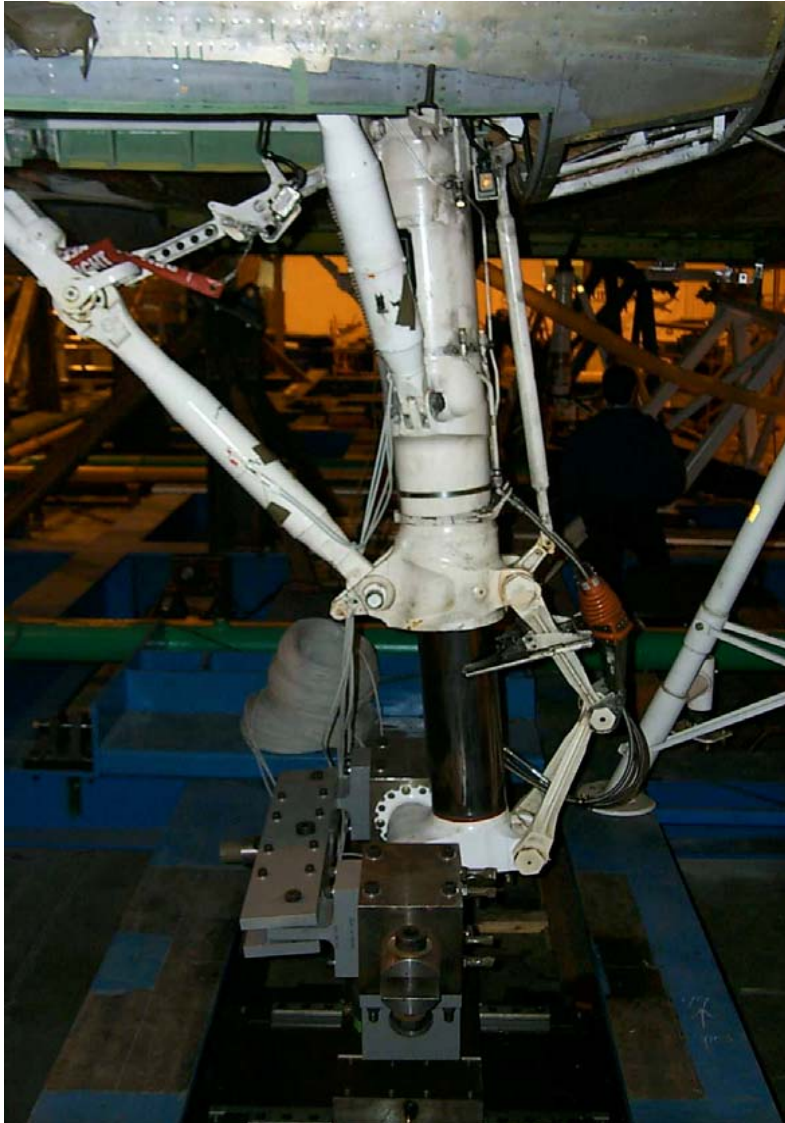
- **To be used in \$70M P-3 aircraft SLAP/SLEP - Full Scale Fatigue Test**
- **R/H MLG chrome plated**
- **L/H MLG HVOF coated**
- **HVOF coating, grinding & processing of gear funded by Naval Research Lab (NRL)**
- **Testing started 30 August 2001 (24 month test)**
- **16,000 Cyclic Test Hrs. accumulated as of 30 Aug. 02**
- **Test down since April '02 for repairs; hope to be up Sept. 02**
- **26,000 CTH planned; ECD December 02 if all goes well**
- **Landing gear shows no sign of coating problems**



HVOF as a Hard Chrome Replacement

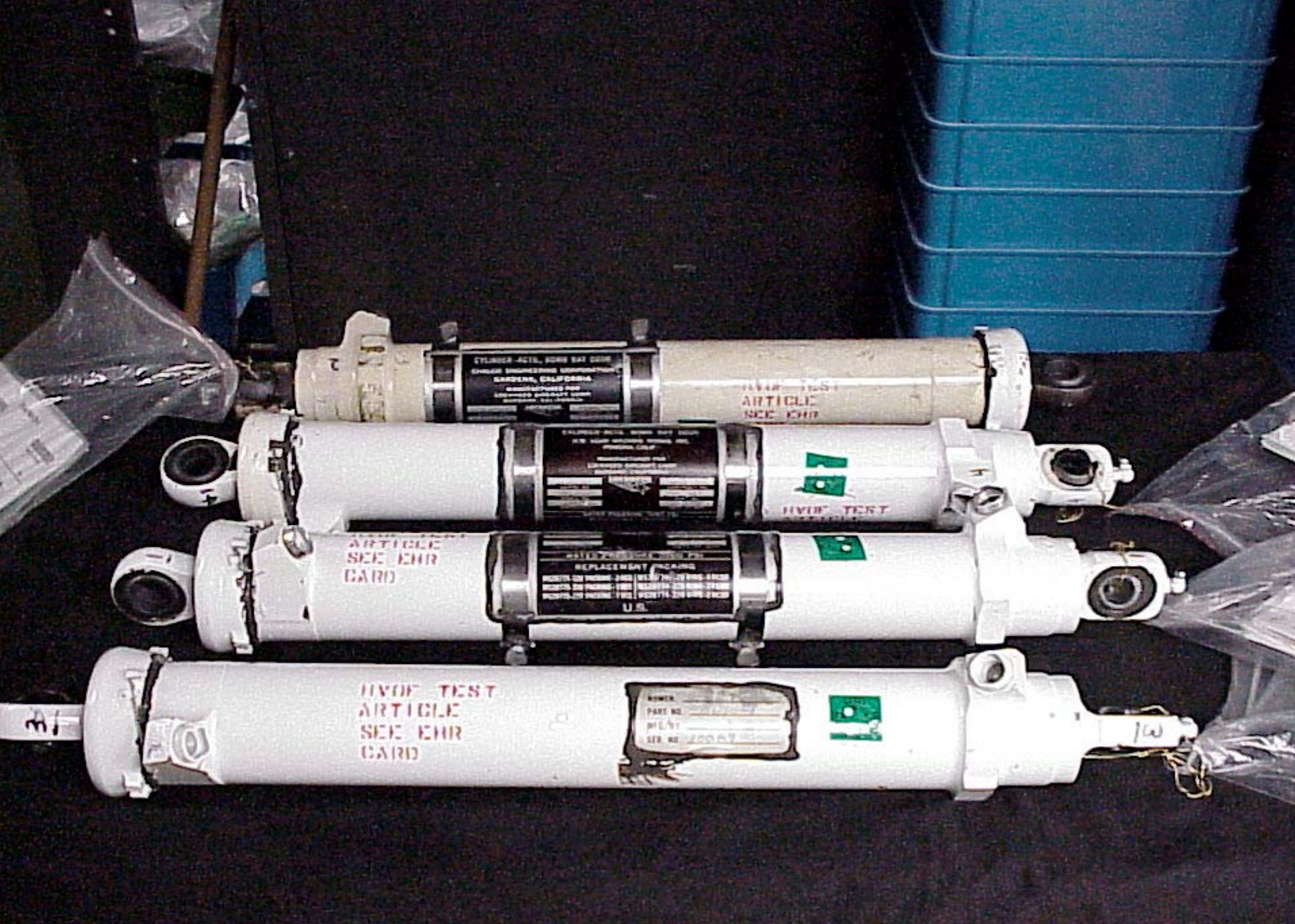


HVOF as a Hard Chrome Replacement



HVOF as a Hard Chrome Replacement

- **P-3 Bomb Bay Door Actuator Pistons coated, ground, & superfinished**
- **Four HVOF coated P-3 Bomb Bay Door Actuator Assemblies RFI and installed on VP-30 Aircraft BuNo 156510 July 2001**
- **Aircraft undergoing PDM at JAX July 2001**
- **A/C delivered back to VP-30 on 7 Sept 01**
- **91 Flight Hours on HVOF coated actuators (01 Feb 02)**
- **232 Flight Hours on HVOF coated actuators (05 Sept 02)**



CYLINDER ACTS, BOMB SAT DOWN
GARDEN, CALIFORNIA

HYDRO TEST
ARTICLE
SEE EHR

REPLACEMENT
U.S.

HYDRO TEST
ARTICLE
SEE EHR

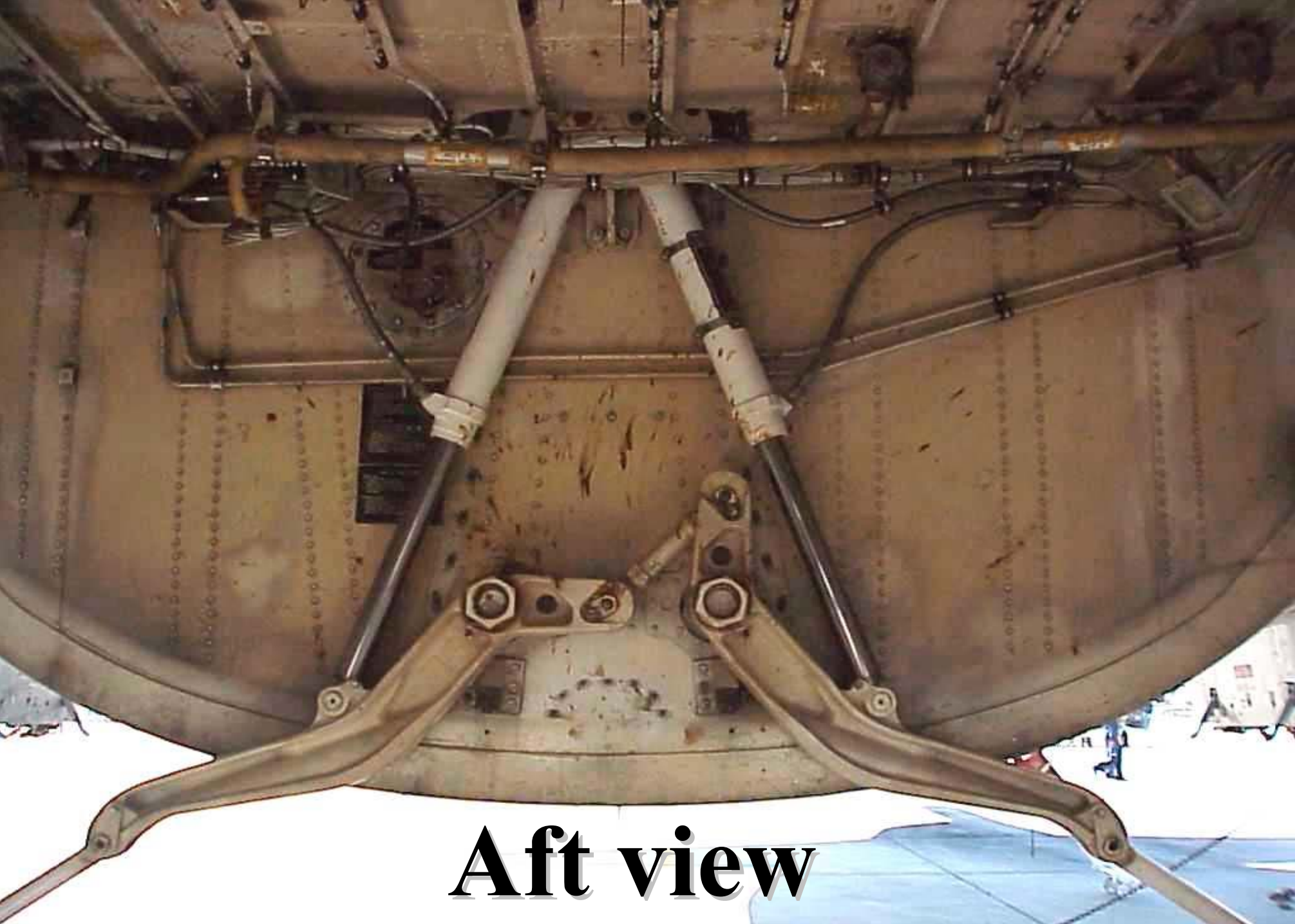
ARTICLE
SEE EHR
CARD

REPLACEMENT
U.S.

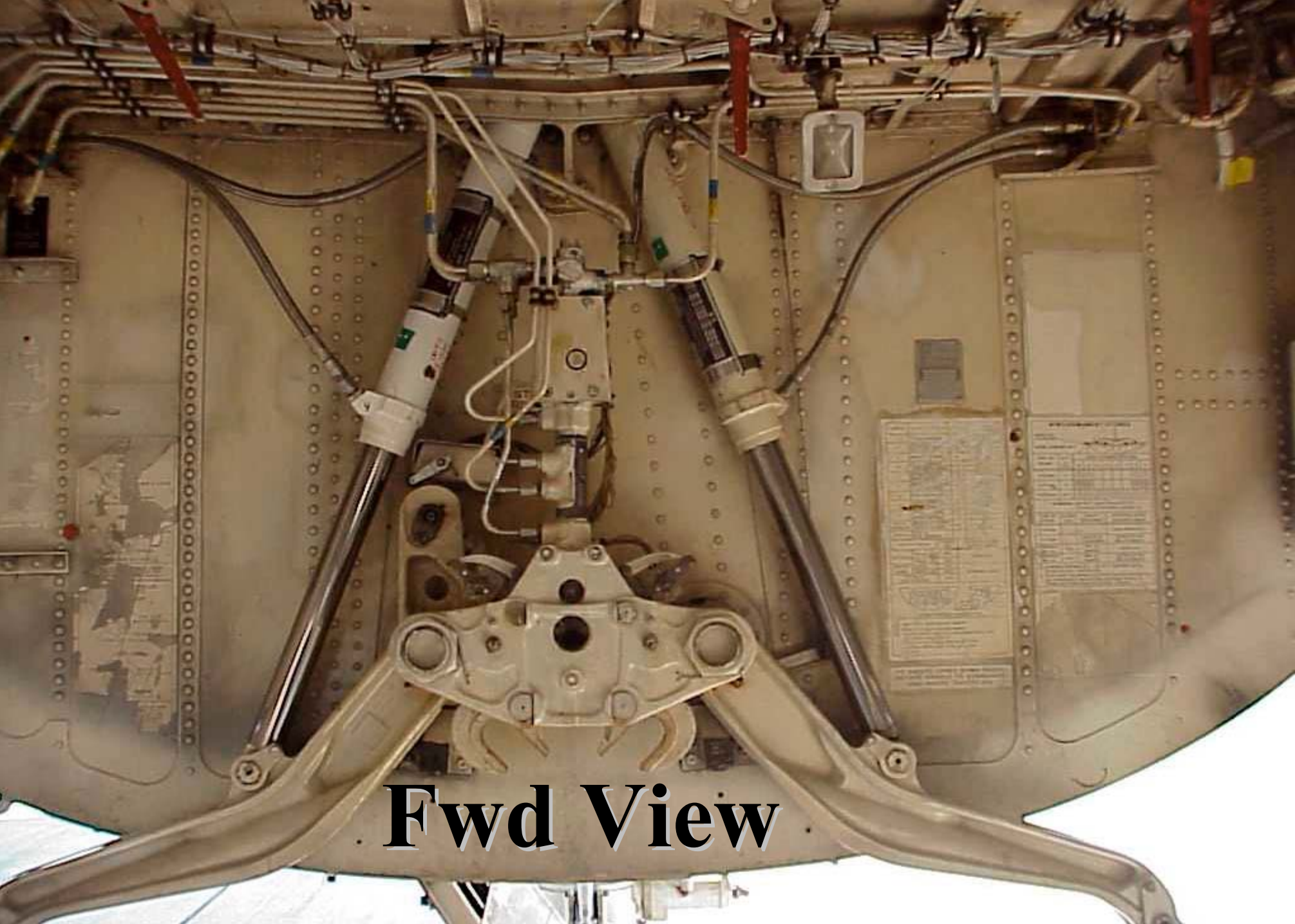
HYDRO TEST
ARTICLE
SEE EHR
CARD

REPLACEMENT
U.S.

HYDRO TEST
ARTICLE
SEE EHR



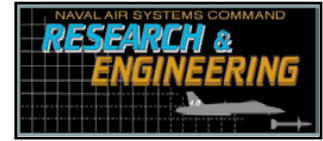
Aft view



Fwd View



HVOF as a Hard Chrome Replacement



Current Status of HVOF Coated EA-6B Main Landing Gear Flight Clearance

MLG Collar and Piston coated Oct. 99

Components completed depot processing Dec. 99

Flight clearance requested Jan 00

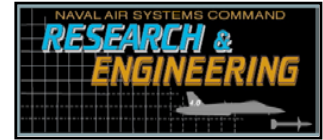
Meeting at NAVAIR/Pax River 13 April 00

Obtained NAVAIR approval of data May 00

Flight clearance at AIR 4.3.3 waiting final approval



HVOF as a Hard Chrome Replacement



“NAVAIR ONLY” HVOF L.G. meeting 16 Nov 00

Flight clearance on-hold

**NAVAIR presented 240KSI requirement for all
landing gear fatigue tests at Dec 00 HCAT mtg.**

NAVAIR & NRL meeting 29 Jan 01

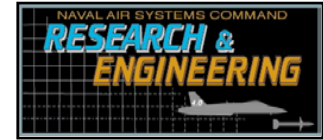
Large sample (2”-3” dia) testing discussed

NAVAIR (Eui Lee) to conduct testing

Flight clearance at AIR 4.3.3 waiting final approval



HVOF as a Hard Chrome Replacement



Meeting at BWI Sheraton 23 OCT 01

Large sample (2 1/4" OD dia) testing discussed

NAVAIR (Eui Lee) to test additional 30 large samples

Must test one NAVAIR large sample with 0.010" coating thickness at max. stress of 200 KSI, actual R-ratio of EA-6B MLG axle to be used during testing

Request to AIR 4.3.3 (Alysha Roerden) for R-ratio & max stress of EA-6B MLG inboard axle journal 23 Oct 01

R-ratio & max. stress from AIR-4.3.3 Feb 02

(200 KSI @ R = -1)

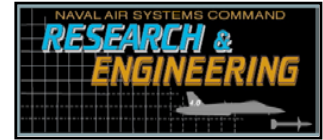
Flight clearance at AIR 4.3.3 waiting final approval

HVOF as a Hard Chrome Replacement





HVOF as a Hard Chrome Replacement



Current Status of E-6A Main Landing Gear

**Two HVOF coated E-6A MLG Uplock Hook Shafts
installed 10 March 99 on A/C 164388**

2,838 Flight Hours (7/31/02) A/C completed

2,480 Landings (7/31/02) Mod in Waco, TX

**One HVOF coated E-6A MLG Uplock Hook Shaft
installed on Aircraft 162784 in Feb. 2000**

3,241 Flight Hours (7/31/02)

2,413 Landings (7/31/02)

HVOF as a Hard Chrome Replacement

E-6A MLG Lock Hook Shaft P/N 9-45196

